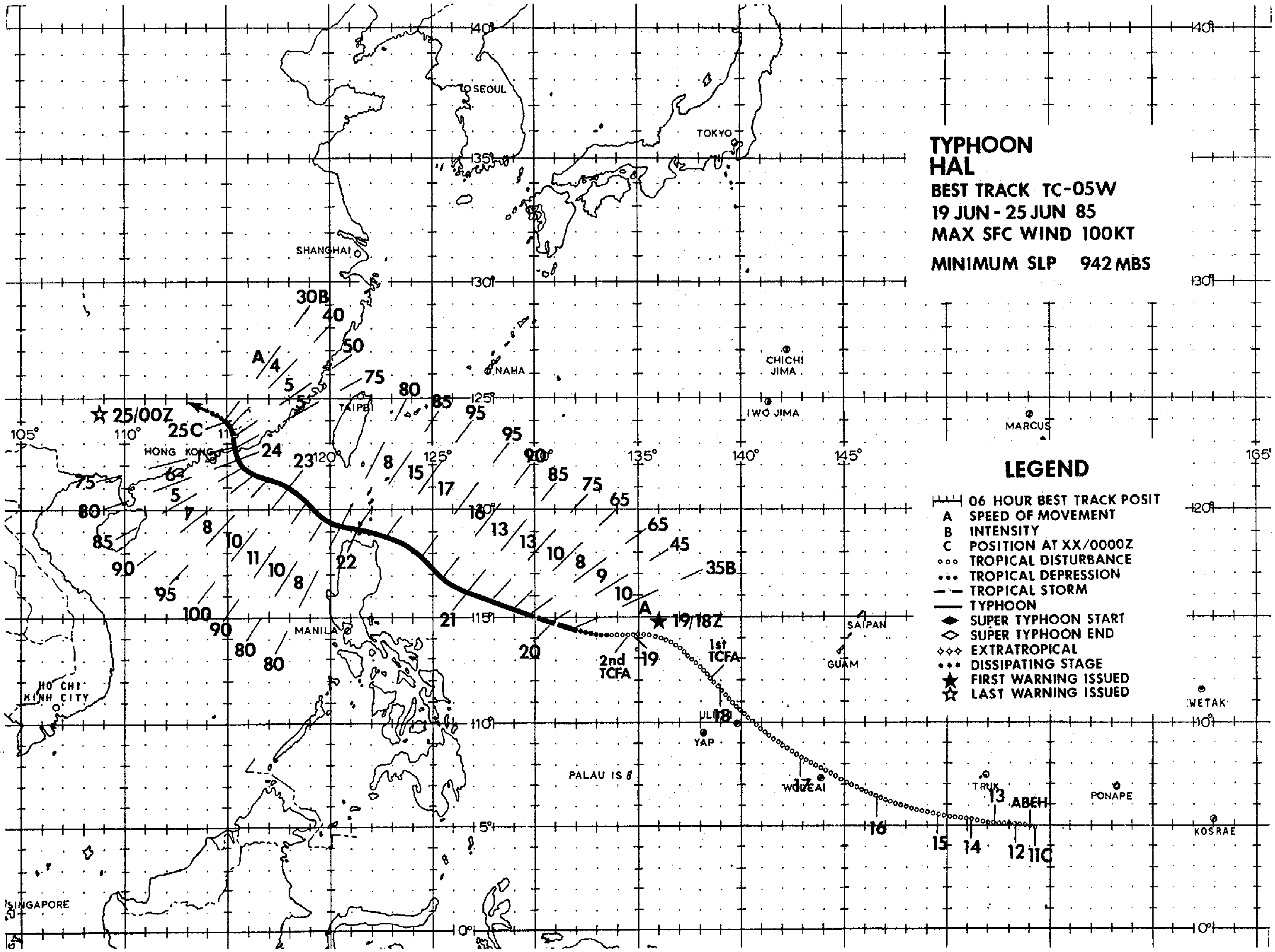

TYPHOON
HAL
BEST TRACK TC-05W
19 JUN - 25 JUN 85
MAX SFC WIND 100KT
MINIMUM SLP 942 MBS
LEGEND
06 HOUR BEST TRACK POSIT
A SPEED OF MOVEMENT
B INTENSITY
C POSITION AT XX/0000Z
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON
SUPER TYPHOON START
SUPER TYPHOON END
EXTRATROPICAL
DISSIPATING STAGE
FIRST WARNING ISSUED
LAST WARNING ISSUED
25/00Z
19/18Z
1st TCFA
2nd TCFA
SEOUL
TOKYO
SHANGHAI
NAHA
TAIPEI
HONG KONG
MANILA
HO CHI MINH CITY
SINGAPORE
CHICHI JIMA
IWO JIMA
MARCUS
SAIPAN
GUAM
ULITHI
YAP
PALAU IS
WOLEAI
TRUK
PONAPE
KOSRAE
WETAK
ABEH

Typhoon Hal, the fifth tropical cyclone of the 1985 WESTPAC season, developed from a southwest monsoon trough disturbance. Hal caused considerable forecast difficulties because JTWC's primary forecast aid, OTCM, was unable to resolve a narrow mid-level subtropical ridge due to its relatively coarse grid spacing.

After Typhoon Gay completed extratropical transition on 26 May, a springtime weather pattern returned to the tropical western North Pacific. A strong tropical upper-tropospheric trough (TUTT) became established over most of the area, resulting in strong surface ridging from the Dateline westward to the Malay Peninsula and a large-scale suppression of convective activity. Transient mid-latitude short wave troughs passed north of a quasi-stationary Polar front that extended from near Hainan Island to about 300 nm (556 km) north of Minami-Torishima (WMO 47991). By 1 June, a weak low-level southwest monsoon flow had returned to the South China Sea. There was a significant surge in the southwest monsoon commencing on 8 June, and by 12 June the low-level southwest monsoon flow extended as far eastward as Guam (WMO 91212).

Typhoon Hal was first detected as a weak tropical disturbance in the near-equatorial trough at 05N 154E on 11 June. The disturbance showed poor organization as it moved slowly westward during the next three days. Most of the intense convection was located west of the low-level circulation center and showed signs of cross-equatorial outflow after 14 June. On the 15th, the disturbance began moving west-northwest and showed signs of increasing organization. By 18 June, the disturbance had merged with the strong low-level southwest monsoon flow and had taken on the characteristics of a monsoon trough disturbance. As shown in Figure 3-05-1, the disturbance was sheared from the north by upper-level flow which left a broad, weak low-level circulation in

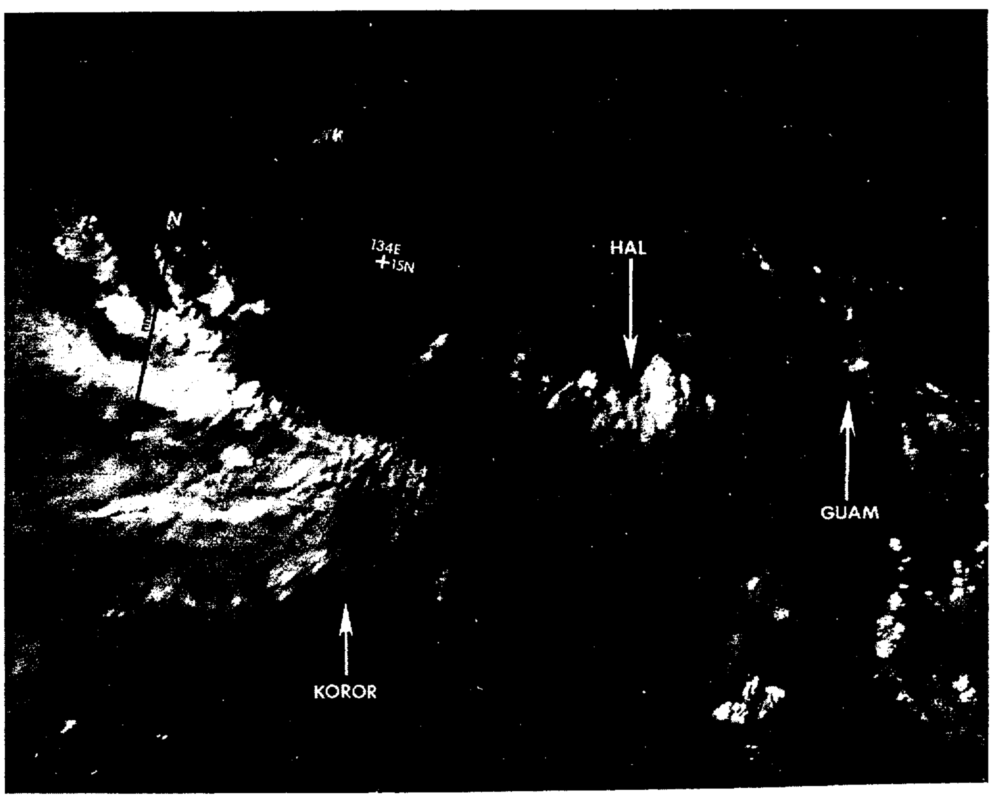

Figure 3-05-1. The tropical disturbance that developed into Typhoon Hal with strong upper-level shear from the north confining the intense convection to the south semicircle. Only scattered cumulus are evident in the north semicircle. The low-level circulation is in the form of a broad trough at this time (180511Z June NOAA visual imagery).

the north semicircle with scattered cumulus clouds. The intense convection was located in the south semicircle where the upper-level flow was divergent toward the southwest. By 1800Z on the 19th, satellite imagery indicated that the upper-level shear from the north had decreased and that a tropical cyclone scale low-level circulation had formed. The system had been the subject of a TCFA for 40-hours when the first warning was issued at 191800Z. Once convection started to appear in the north semicircle and the system showed signs of cirrus outflow toward the north, intensification proceeded quickly. By 200600Z, only 12-hours after the first warning, the cyclone had reached typhoon intensity. Figure 3-05-2 shows a plot of the aircraft reconnaissance mission flown at that time. Notice the location of the maximum surface winds. In this case, the maximum surface winds are located approximately 90 nm (167 km) from the center of the cyclone. This large separation is a characteristic of many cyclones that evolve from strong monsoon troughs. Typhoon Hal continued intensifying during the next 24-hours and developed a large, ragged eye as shown in Figure 3-05-3. This feature is also a characteristic of this type of cyclone. The satellite picture also shows a TUTT cell located east of

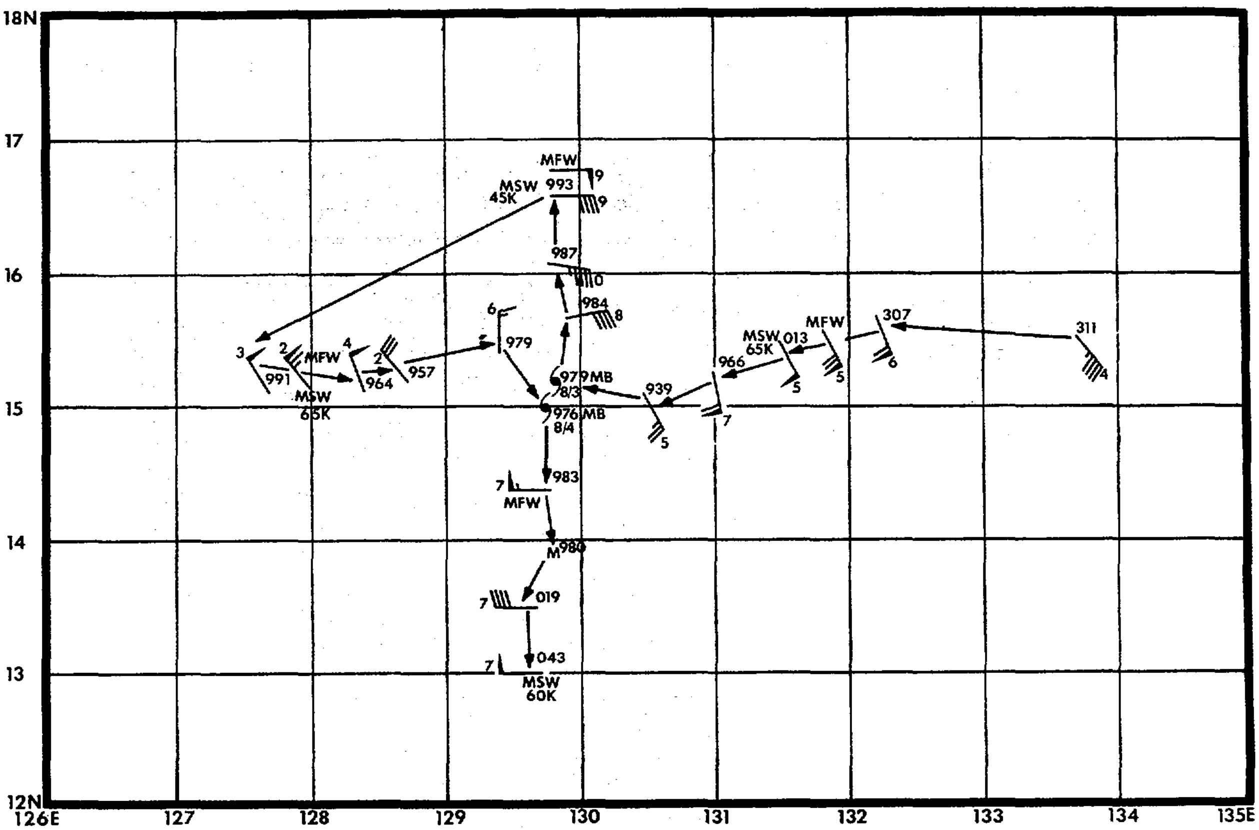

Figure 3-05-2. Plot of aircraft reconnaissance data from 200500Z to 201000Z June showing the maximum surface winds located approximately 90 nm (167 km) from the cyclone center. "MFW" represents the maximum observed flight level winds and "MSW" represents the maximum surface winds observed.

Figure 3-05-3. Typhoon Hal with a large, ragged eye. Most of the intense convection is in the south semicircle. (210109Z June DMSP visual imagery).

Hal that enhanced the upper-level outflow pattern in that direction. Figure 3-05-4 shows Typhoon Hal near the time of its maximum intensity.

Except for a few short-term variations, Hal moved in a west-northwestward direction during its five-day lifetime as a tropical storm and typhoon. This is interpreted in post-analysis as a normal south-of-the-subtropical ridge track movement. Figure 3-05-5 shows the 500 mb wind pattern at 201200Z, 18-hours after the first warning was issued, but still representative of the environment present throughout Hal's lifetime. Note the narrow sub-tropical ridge north of Hal that extends westward towards China. Based on just this pattern and assuming that it would persist, a forecast track of west-northwest would have been a good choice. However, JTWC's primary forecast guidance, the OTCM (One-way Interactive Tropical Cyclone Model)

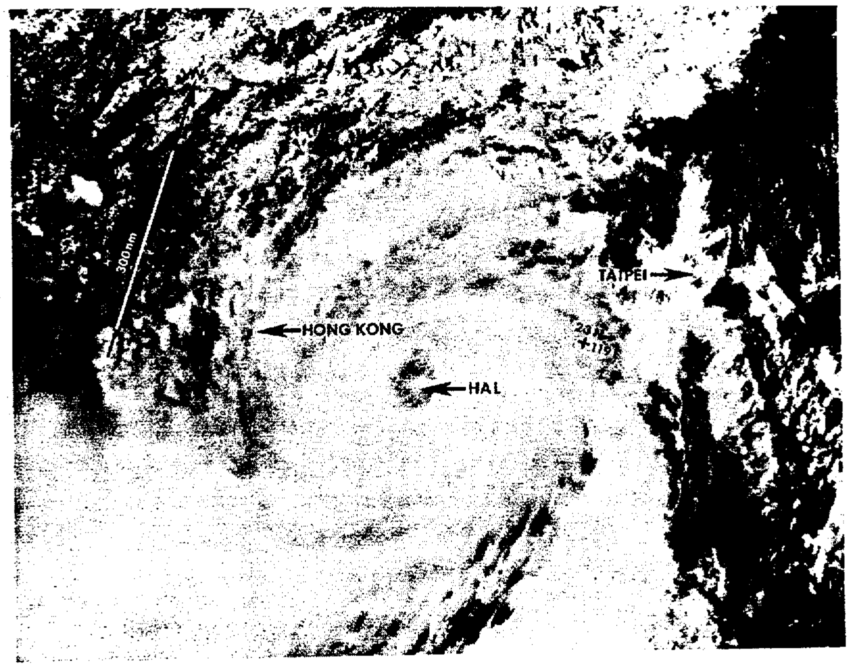

Figure 3-05-4. Typhoon Hal near the time of maximum intensity (230559Z June NOAA visual imagery).

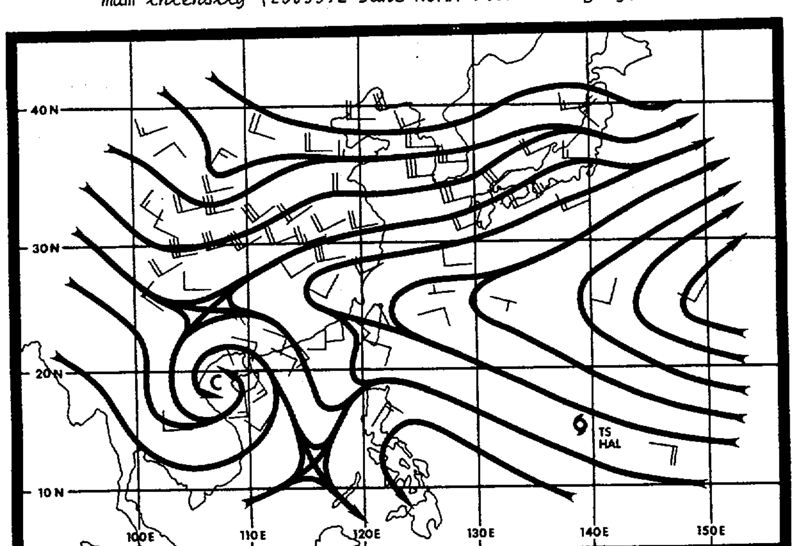

Figure 3-05-5. The 201200Z June 500 mb analysis showing the narrow mid-level subtropical ridge north of Hal. This ridge kept Hal from taking a more northerly course and entering the westerlies, contrary to the guidance provided by OTCM.

consistently indicated a more northward, and even a recurving northeastward, track. Figure 3-05-6 is a plot of the OTCM forecast tracks starting with the one on which the first warning was based. JTWC followed the guidance offered by the OTCM, and as a result, the forecast tracks were consistently north of Hal's actual track. In post-analysis it is apparent that OTCM was unable to resolve the narrow mid-level ridge because of the relatively coarse grid size (205 km) that the model uses. The flow that OTCM "saw" influencing the movement of Hal was the westerlies on the north side of the ridge. This resulted in the northward and recurving component in the OTCM forecasts. This situation will likely arise again in the future years, and will be closely watched for by the forecasters at JTWC as a result of this experience.

The Philippine island of Luzon experienced the strongest effects as the center of Typhoon Hal passed just 30 nm (56 km) off the north coast and westward through the Luzon Straits. The death toll was 23 persons with nine others reported as missing. There was widespread flooding and crop damage. Total damage was estimated at more than $10 million. Eight crewmen of the US Navy frigate Kirk (FF-1087) were injured when a large wave crashed over the bow. The ship was operating in the South China Sea about 5 nm (9 km) southwest of Subic Bay. High winds caused superficial damage to the hull of the destroyer USS Oldendorf (DD-972) when a drifting, unmanned barge struck the ship while it was moored at Subic Bay. Strong winds tore the barge from its mooring in mid-harbor shortly before the incident occurred. As Typhoon Irma approached from the east, Subic Bay received 30 in (762 mm) of rainfall during the period 26-28 June as a result of the strong low-level southwest monsoon flow that continued over the area after Hal had moved into China and dissipated as a significant tropical cyclone.

Taiwan was also affected by Typhoon Hal as it caused strong winds and heavy rains. Two people died, 18 injured, and five people listed as missing as a result of the typhoon. Eastern Taiwan experienced the heaviest rainfall, with almost 9 inches (229 mm) being reported. The heavy rainfall caused flooding that was responsible for most of the death, injury, and damage.

Typhoon Hal made landfall approximately 75 nm (139 km) east-northeast of Hong Kong (WMO 45005) at 240500Z. Maximum mean hourly wind speed reported at the Royal Observatory was 22 kt (11 m/s) from the west-northwest, with a peak gust to 49 kt (25 m/s). A gust to 50 kt (26 m/s) was recorded at the Hong Kong International Airport (WMO 45007). Some minor injuries were reported and the property damage was slight. All modes of transportation were disrupted on 23 and 24 June. Heavy rain on 25 and 26 June, after Hal had moved inland, caused numerous landslides in the Hong Kong area with only a few minor injuries.

Over mainland China, 13 more people died with some 40,000 homes and 321,000 acres (130,000 hectares) of crops damaged.

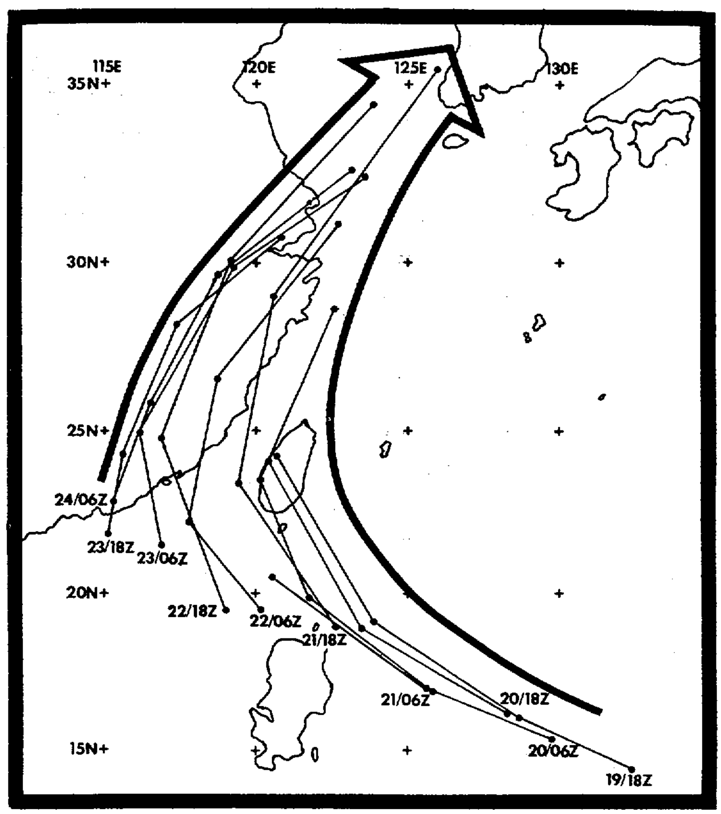

Figure 3-05-6. Plot of the OTCM (One-Way Interactive Tropical Cyclone Model) forecast guidance at 12-hourly intervals starting when the first warning was issued.